Clean energy mini-grids for Africa's poor, rural communities

The role of development practitioners in attracting financing

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Abstract

To be completed.

Acronyms

AC	Alternating current
AGECC	Advisory Group on Energy and Climate Change
BoP	Bottom of the pyramid
CDM	Clean Development Mechanism
DC	Direct current
DRC	Democratic Republic of the Congo
IEA	International Energy Agency
IFAD	International Fund for Agricultural Development
IFC	International Finance Corporation
KW	Kilowatt
KWh	Kilowatt-hour
KVa	Kilovolt-ampere
MDG	Millennium Development Goal
MWh	Megawatt-hour
NGO	Non-governmental organisation
OBA	Output-based aid
O&M	Operation and maintenance
PPA	Power purchase agreement
PPP	Public-private partnership
PV	Photovoltaic
RE	Renewable energy
SBI	Sustainable Business Institute
SME	Small and medium-sized enterprises
SPD	Small power distributor
SPP	Small power producer
TWh	Terawatt-hour
Wp	Watt-peak
WTP	Willingness-to-pay

1. Introduction

1.1. Relevance

'Energy is a critical enabler. Every advanced economy has required secure access to modern sources of energy to underpin its development and growing prosperity. While many developed countries may be focused on domestic energy security or decarbonising their energy mix, many other countries are still seeking to secure enough energy to meet basic human needs. In developing countries, access to affordable and reliable energy services is fundamental to reducing poverty and improving health, increasing productivity, enhancing competitiveness and promoting economic growth' (IEA, 2011).

The IEA claims that over 40%, i.e. approximately 400 Terawatt-hour (TWh), of all capacity to achieve universal access to electricity by 2030 will be most economically provided through mini- and micro-grids; village, town or district electrical generation and distribution networks either unconnected to, or able to operate independently, from the main electricity grid (IEA, 2011). The remote and isolated locations of many of the communities that will be served through these systems, accompanied by the cost reductions in renewable energy technologies, make way for small and clean electricity systems for creating access to electricity for all. Even with those technological breakthroughs, practice has shown that the velocity at which clean energy mini-grids, with a minimum of 75% generated through renewables, are being deployed and financed remains off-track to achieve the 2030 target (SE4ALL, 2014).

1.2. Problem description

With over 620 million people lacking access to electricity in 2012, Africa has nearly half of the world's population living without modern electricity facilities. It is also the only world region in which this number is increasing; despite the efforts to equip African communities with electricity they have not been able to offset the rapidly growing population. Still, nearly 80% of the rural population lacks access to electricity, totalling approximately 500 million people (IEA, 2014). For the period 2010-2030 the IEA calls for an annual investment of US$ 7,0 billion on top of the already agreed upon measures and intentions to secure access to reliable mini-grid systems for all rural African communities (IEA, 2011).

If being the poorest continent in the world was not enough, Africa faces several other challenges. Two of those that are highlighted and discussed in this study are the lack of proven business models as well as the absence of private and public investors. Both issues form a downward spiral; one cannot exist without the other. To ensure universal access to electricity by 2030 we must prioritise the financial viability of mini-grids, both in the short and long run. How to increase and secure the financial aspects of mini-grids in a practical fashion has so far not led to universal conclusions. And, while much of the literature suggests various solutions they often entail general approaches rather than project specific guidelines.

1.3. Objectives and research questions

This study aims to gain understanding of the steps needed to catalyse financial resources for the implementation and sustainability of clean energy mini-grids for poor, rural communities in Africa. The author's approach is centred on the role of development practitioners due to their focus in developing countries. Development practitioners are characterised in this study as non-profit organisations that deliver services directly to people at the bottom of the pyramid (BoP), whose incomes are less than US$ 2,50 per day (World Bank, 2015). Considering the fact that most of Africa's rural communities fundamentally lack the resources to create, maintain and expand electricity services on their own, the main specific objective of this study is to articulate a framework providing the steps needed to secure financial sustainability of clean energy mini-grids. Although the aim of the framework is to be adopted by development practitioners, its purpose could be of interest to other actors directly and indirectly active in mini-grids, such as researchers and financing institutions. In search of possible answers and fulfilment of the objective this study adopts the following research question:

Research Question	To what extent can development practitioners help to attract financing for clean energy mini-grids for Africa's poor, rural communities?

It is necessary to further clarify the pathway of this study, i.e. its scope and boundaries. It ensures the research is structured in a logical way and, not less important, it enables a thorough understanding of the material by the reader as well as a critical attitude towards it. The author therefore dives deeper into the relevance and definition of clean energy mini-grids through analysing: the specific socio-economic context of rural Africa, a comparison of rural electrification options including the services they create for people at the BoP, and the economics of clean energy mini-grids. See sub-question 1:

Sub-question 1	What are clean energy mini-grids and what is their relevance for poor, rural African communities?

In order to fully grasp how mini-grids should be financed we need to articulate the underlying key requirements that make mini-grids functional. The author aims to integrate technical, social, economic, and regulatory dimensions. Sub-question 2 is put in place to provide answers to these issues. Identification of the key issues helps to clarify the role of development practitioners.

Sub-question 2	Which key issues need to be addressed for clean energy mini-grids to be able to create economic development?

While the first two sub-questions aim to reach a general understanding of mini-grids we delve deeper into the central topic of this study, i.e. achieving financial resources for mini-grids. The latter statement is divided into three scopes of research. Firstly, we need to know the size of financial requirements for mini-grids and when they are most likely to occur throughout the lifespan. Secondly, this study aims to identify different types of investors, including associated financial products, as well as risk and return preferences. Thirdly, once we have an overview on investor types and financial products it is essential

how to link these specifically to the mini-grid key issues. Simply said, the analysis should figure out how to balance financial demand and supply, since the financial requirements for mini-grids need to match the wishes of investors and vice versa. See sub-question 3.

Sub-question 3	How can additional financing address those key issues?

Although financing is needed to ensure successful implementation and financial sustainability of mini-grids we also need to find out what kind of services development practitioners deliver towards these processes, see sub-question 4. The analysis focuses solely on the services that have a clear and direct added value for mini-grids. Equally important is to understand their role compared to other stakeholders.

Sub-question 4	What is currently the role of development practitioners in the implementation of mini-grids?

The fifth sub-question is used for discussing the opportunities for development practitioners to be more prominent in terms of attracting financing and investors for mini-grids. The analysis builds upon the current role of development practitioners and aims to find out how development practitioners can link the various types of investors to mini-grids.

Sub-question 5	How can development practitioners help to improve participation of investors?

1.4. Outline

The remainder of this study adopts the following outline. In chapter 2 is presented the methodology used by the author for the analysis. Chapter 3 and 4 comprise a literature review, focusing on the key issues of mini-grids and the financing thereof respectively. Results are presented in chapter 5, followed by a discussion in chapter 6. The previous sections shall feed into chapter 7 for recommendations and conclusions. References and annexes can be found in chapter 8 and 9 respectively.

2. Methodology

The methodology for the analysis can best be explained along with figure 1. The methodological framework differentiates five steps, and logically follows the main and sub-research questions. These steps are as follows:

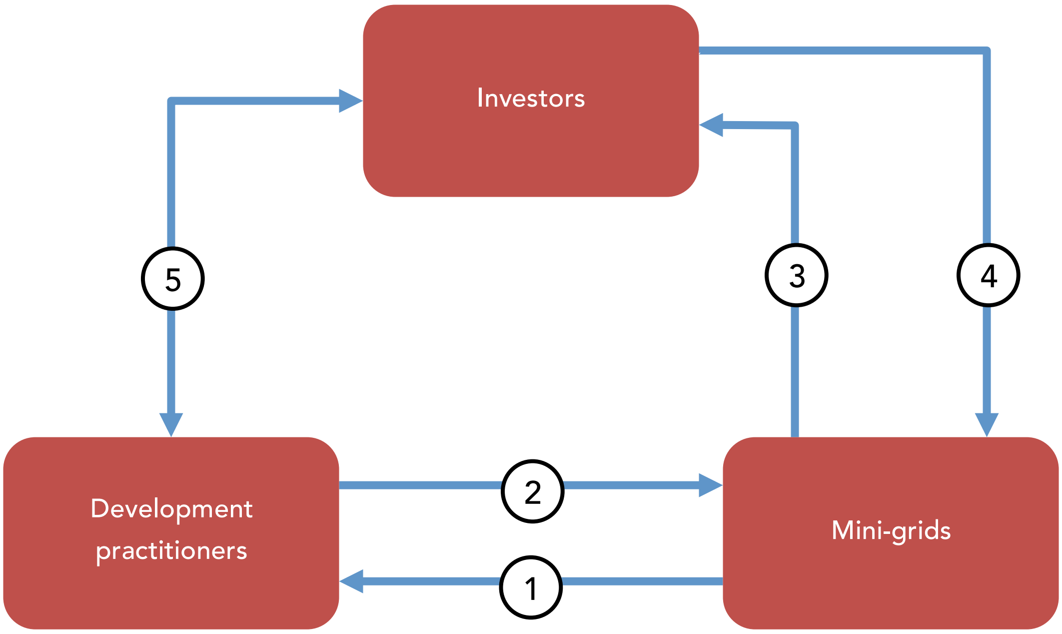

Figure 1. Methodological framework.

Step 1 focuses on the practical requirements that are needed to ensure successful implementation and operational sustainability of mini-grid projects. The flow from mini-grids to development practitioners implies that it is crucial for stakeholders to understand how mini-grids work. A literature review is performed to obtain lessons learned concerning mini-grids and to identify the key issues needed to ensure functional mini-grids.

Step 2 feeds back from development practitioners to mini-grids. It aims to identify the services development practitioners bring to mini-grids. The author has deliberately chosen to narrow the scope down to those services that have a clear and direct added value to mini-grids. In first instance, project documentation of 5 different mini-grid projects from SNV Netherlands Development Organisation is analysed to discover relevant services. Locations include Peru, Nepal, Democratic Republic of the Congo (DRC), Zimbabwe and Rwanda. In addition, an online questionnaire is created to identify services from other development practitioners, i.e. GVEP and Practical Action. The purpose is to compare services and to make a preliminary conclusion on the role of development practitioners in mini-grids. The online questionnaire is build upon the services detected from the analysis of the project documentation of SNV Netherlands Development Organisation. Furthermore, an interview with a former Director of the Alliance for Rural Electrification (ARE) and author of *'Hybrid mini-grids for rural electrification: lessons learned'* is conducted to learn about the role of development practitioners in mini-grids. This interview is complementary to the results obtained from the previous two analyses, but takes a broader perspective.

In step 3, the author analyses the financial requirements of mini-grids to understand how to ensure successful implementation and financial sustainability. For this, the author examines mini-grid costs forthcoming from the literature, such as related to the infrastructure set-up and operation and maintenance (O&M). A comparison between clean energy and conventional energy-based mini-grids is also made. In this study an additional analysis is made based on financial data of the mini-grid project in Zimbabwe supported by SNV Netherlands Development Organisation, which is subdivided into 5 project sites. The main reason for this focus is that this pilot project strives to achieve a business model that ensures financial and economic sustainability in rural areas in Zimbabwe.

Step 4 is closely linked with the previous step, and concentrates on the perspective of different types of investors. It aims to identify under which conditions they would be willing to invest in mini-grids. A literature review summarises the types of investors and associated financial products, and takes into account characteristics such as return on investment, risk profiles, among others. Interviews with investors enable a comparison between literature and practice. Investors that were being considered for the interviews are local financing banks, international financing institutions and the private sector. Another important element to analyse is the inclusion of local communities' equity. Based on a brief literature review this study identifies the willingness and ability to pay of communities to invest in mini-grids. The Zimbabwe case study is used to compare these numbers and drafts an indication to what extent communities are capable of financing mini-grids themselves.

Step 5 is used to understand how investors secure their anticipated return on investments and minimise risks once they made a commitment to participate in mini-grids. Here, the author examines what the (potential) role is of development practitioners in assisting investors. Taken a step further, the author articulates how development practitioners can influence investors to participate in mini-grid projects. An interview with a mini-grid project leader and financial expert of SNV Netherlands Development Organisation is used to learn about the role of development practitioners in attracting investors and securing financing for mini-grids for people at the BoP.

A final remark here, and at the same time an important aspect, is to foresee and overcome challenges that could impede the analysis. One of them is the lack of available financing data on the direct costs flowing from the services provided by development practitioners and the benefits for mini-grids. A possible solution is to inquire data from SNV Netherlands Development Organisation. A second issue arises from the complexity and context-dependency of mini-grids. The author should be cautious in drawing general conclusions for mini-grids. The literature review as well as interviews with different stakeholders can be of help. Thirdly, the same applies to the services of development practitioners. This study aims to take into account merely three development practitioners due to the limited timeframe in which this research takes place. Fourthly, this study does not attempt to draft an analysis of all stakeholders involved in mini-grids. This would simply take too much time and is beyond the scope of the research. Again, this means the author should be cautious when making conclusions.

3. Clean energy mini-grids for Africa

3.1. Electricity as driver to socio-economic development

In 2010, over 635 million African people lived in rural areas, representing almost 62% of Africa's total population. A vast majority consisting of 480 million people are still excluded from the benefits of so-called modern energy services, including electricity, to meet their needs. Problems are most critical in sub-Saharan Africa, where many nations find at least 75% of the rural population unelectrified, see figure 2 (World Bank, 2015). Although there is no universally agreed definition of modern energy services, we can say that it includes access to reliable, affordable, sustainable and low carbon-emitting energy sources for households, enterprises and public services. In essence, these modern energy services should create access to improved conditions for social and economic development as well as to enable the poorest of the poor to escape poverty (AGECC, 2010; IEA, 2011). If we want to give this –rather vague- definition a little more shape we need to understand the incremental levels of services it aims to achieve. These can be divided into: basic human needs, productive purposes and modern society needs. See figure 3 for each of the accompanying energy services they support (AGECC, 2010). According to this definition, modern energy needs exhibit 20 times more electricity consumption compared to basic energy needs, namely 2.000 kilowatt-hour (kWh) and 100 kWh per capita per year respectively.

A World Bank evaluation study reported on the benefits of rural electrification services in developing countries (World Bank, 2008b). The benefits are:

- Benefits from lighting, TV and radio.
- Education benefits, which results in higher future earnings.
- Leisure time as a consequence of timesavings. The benefits are expressed as opportunity costs for giving up work, namely the average wage.
- Productivity of home businesses, which includes net revenues from both new and existing businesses.
- Agricultural productivity, calculated as additional revenue.
- Improved health as a result of improved indoor air quality from reduced kerosene use.
- Reduced fertility arising from knowledge from channels with access to electricity.
- Public good benefits, such as improved security and positive climate change mitigation effects.

Each of these benefits were quantified for four countries, namely the Philippines, Peru, Laos and Bolivia, see table 1 in appendix 9.1. While 4 countries alone cannot reliably predict the benefits in other countries, there are other drawbacks to the results. None of the countries are African nations, and are thus likely to misrepresent the African context. We also see that total benefits vary widely across countries, from US $19,32 to US$ 53,78, but this might be a result of the low number of investigated subjects. Other, more intangible benefits such as climate change mitigation effects were not measured, and again lower the reliability of the data. It would also be interesting to compare the net benefits of clean energy options versus diesel-based generators, especially for health and climate change indicators.

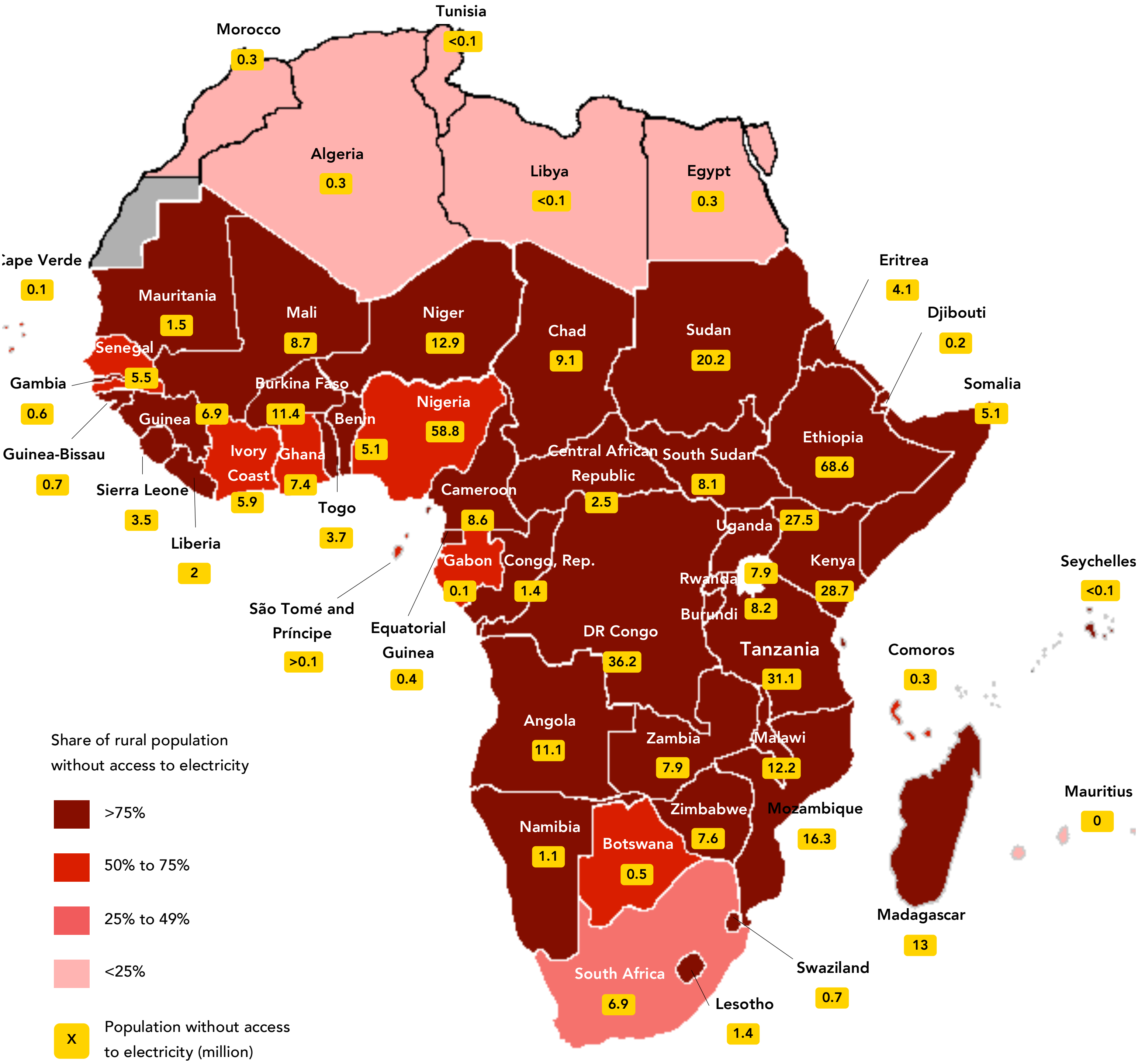

Figure 2. Lack of access to electricity in rural Africa. Source: World Bank (2015).

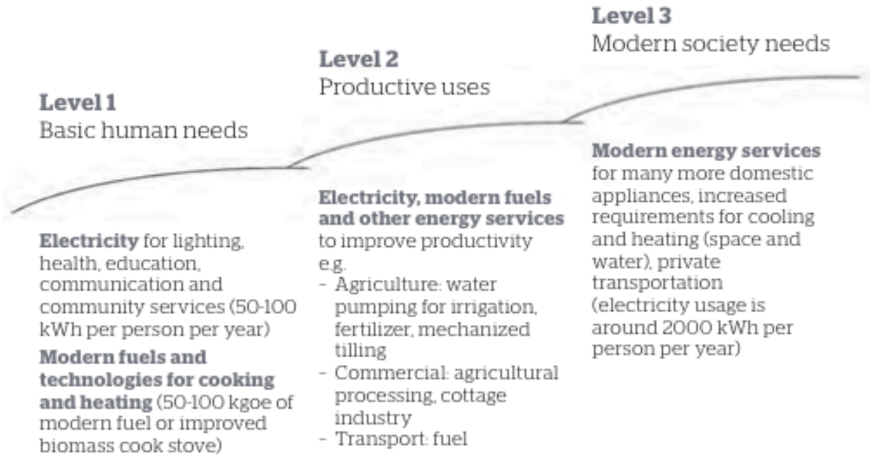

Figure 3. Modern energy services. Source: AGECC (2010).

Let us take a look at the data calculation itself. At least five points for discussion can be distinguished. First of all, double counting might exist, such as the educational benefits through television. Secondly, calculations are prone to methodological choices. Benefits through lighting, television and radio are based on a non-linear consumer surplus model and differs when using a linear-based model (World Bank, 2008b). Thirdly, 'timesavings' are calculated based on the opportunity cost of labour, which is the point where people are indifferent between working one additional hour and receiving an hour extra leisure time. In poverty areas it is unlikely that people have a rational choice between the two. Poverty means labour is absent (at least partly) and the opportunity cost of labour is therefore negligible. Fourthly, the benefits do not include cost savings from fuel, if present at all. Fifthly, there are no equity-indicators measured, such as for gender issues. The time spent on collecting firewood for energy services for rural households is above 2,5 hours per day on average, but varies considerably from country to country, e.g. 0,13 hours in Burkina Faso up to 8 hours in Guinea. Theoretically, if electrification leads to reduced use in firewood it implies timesavings for households, e.g. for education and leisure opportunities, especially for women (World Bank, 2008b). Their benefits should therefore be taken into account (UNDP, 2011). However, firewood is most often used for cooking, and a majority of the African nations do not yet have implemented electricity-based alternatives.

3.2. Rural electrification options

Mini-grids provide a decentralised energy solution at a local level, using a small distribution network compared to grid-connected systems. But are mini-grids really the solution for achieving these services successfully, and how do they relate in comparison to other rural electrification options? First of all, let us begin with deriving the energy needs that seems appropriate for rural African communities. A threshold level for electricity consumption is estimated at 250 kWh per year per five-person based households. This includes a mobile phone, a floor fan and two compact fluorescent light bulbs working five hours per day (IEA, 2011). Productive uses, and other advanced uses (e.g. cooling), are needed to sustain long-term sustainable development. Energy consumption should therefore grow steadily, especially in the first five years of implementation. By 2030, all newly

connected rural households should have a consumption level of 4.000 kWh per year (800 kWh per capita), which is similar to the trend currently experienced in much of developing Asia (IEA, 2011).

To meet these demands communities can make use of three electrification alternatives, namely stand-alone systems, mini-grids, and grid-connected systems, see table 1. Stand-alone systems are able to meet basic human needs, whereas mini-grids and grid systems are able to provide also productive uses and community services (Valer, Mocelin, Moura & Nascimento, 2008). Each of these options exhibits unique advantages and disadvantages, depending on the needs and context of rural communities. A rule of thumb suggests that rural areas that are at least 5-10 years away from receiving grid electricity are generally candidates for renewable energy mini-grid systems (World Bank, 2008b). Furthermore, mini-grids can be considered the most viable option for the medium to long run for most of Africa's rural communities since they can be adapted to the local context and to the wishes of the community, are generally the most cost-effective option in the long run, and allow for future consumption growth (IED, 2013; Yadoo & Cruickshank, 2012; RECP, 2014). However, there is no literature available that accurately tries to pinpoint when mini-grid are the most viable option. This is due to a lot of factors that need to be taken into account, such as the size of communities, population density, the distance to the grid, terrain complexities and economic significance, among others (RECP, 2014).

Table 1. Description of rural electrification options. Sources: ARE (2011), IED (2013), RECP (2014) and (Valer, Mocelin, Moura & Nascimento, 2008).

	Stand-alone systems	Mini-grids	Grid extension
Definition	Mostly small diesel gensets or solar systems directly installed at the individual end-user and requires no distribution network	Typically used in isolated locations and connects a limited number of consumers through a small generation and distribution system	An interconnected national or sub-national grid, often with a far-reaching transmission network. Able to support large communities
Capacity	0 – 5 kW	Usually 5 kW – 150 kW, although 10 MW exists	No information available
Services	- TV - Radio - Small fans - Small light bulbs	- TV - Radio - Fans - Small and large lighting options - Refrigerator - Small productive equipment	- TV - Radio - Fans - Small and large lighting options - Refrigerator - Small and heavy productive equipment

3.3. The economics behind clean energy mini-grids

Mini-grids offer an outstanding solution for utilisation of Africa's renewable energy sources, such as Photovoltaic (PV), wind and small hydropower (IED, 2013; Rolland & Glania, 2011). By 2030, PV is expected to deliver 37% of power output in newly installed mini-grids. In combination with wind and hydro-powered facilities they will power around two-third of the mini-grids in Africa's rural areas. Diesel generators on the other hand are likely to be designated a share of 32%, such as in countries with low diesel prices (IEA, 2011). Though the average pump price for diesel fuel in 2012 was around US$ 1.21 per litre on the continent, some countries experienced prices of US$ 0.20 per litre (e.g.

Egypt, Morocco) whereas others reached prices well over US$ 1.70 per litre (e.g. Eritrea and South Sudan) (World Bank, 2015). For the latter countries, clean energy mini-grids would make more sense economically. A rule of thumb suggests that clean energy mini-grids are economically attractive with a diesel price above US$ 0.70 per litre (Rolland & Glania, 2011).

From an economic point of view it is rational to conclude that renewables will represent such a large share in mini-grid power output in the near future. A study by Yadoo & Cruickshank (2012) shows that 100 kW diesel-based mini-grids need to run on 80% capacity in order to compete cost-effectively with similar-sized hydro and PV-wind mini-grids functioning at 30% capacity. This comparison is based on the calculation of the total capital and O&M costs divided by the lifetime of the technology, usually 20-30 years (Rolland & Glania, 2011). Renewable and diesel-powered mini-grids differ in this respect. Diesel-based generators require low initial investment but bear much higher O&M and fuel costs in comparison to renewables. The high upfront investment is one of the issues hindering implementation of clean energy mini-grids. One possible solution is to combine both technologies to make it a hybrid mini-grid. Another solution is by making use of storage devices such as batteries. A 75-99% renewable energy-based mini-grid lowers the initial investment barrier and allows continuous electricity generation in case of zero renewable energy production (ARE, 2013; Rolland & Glania, 2011; World Bank, 2008b).

3.4. Key implementation issues to make mini-grids work

Additional lessons can be drawn from the literature when it comes to the practical implementation of mini-grid systems. They are related to the governance, social, economic and business aspects that contribute to community development. More specifically, inclusion of these ancillary factors should aim to secure access to electricity for current and future generations, enhance management and effective use of electricity, as well as to contribute to the scaling up of mini-grids.

3.4.1. Governance issues

When mini-grids are to be implemented they should adapt to the demands of the local population rather than the locals adapting to the envisaged project. To be successful, projects must respect local traditions and local leadership structures, especially in cultures where relationship building is important. Local involvement and participation is also essential; in a market with lack of local awareness and untested renewable energy technologies it is crucial to experiment (Peskett, 2011).

Another governance element that has taken a dominant position in recent literature is business, or ownerships models. Ownership is often closely linked to the actor who is responsible for the implementation and O&M (Rolland & Glania, 2011). Four ownership models can be distinguished: the community-, private sector-, utility-, and hybrid-based model. Each of these exhibit unique advantages as well as disadvantages, see table 2 below.

Table 2. Advantages and disadvantages of different mini-grid business models. Sources: ARE (2011), RECP (2014) and Peskett (2011).

Model	Advantages	Disadvantages
Community	• Increase ownership, which improves operation and maintenance • Can be more efficient than bureaucratic utilities	• Communities may lack technical and business skills (e.g. design and installation; tariff setting), leading to higher costs to bring these in • Governance of systems needs to be well managed; corruption risk due to overlap of management and social and family structures
Private	• Greater efficiency • May have capacity to offer better O&M services • May be better able to navigate political interference • Allows scalable operations	• Lack upfront financial support in most cases • Often difficult to find experienced companies; schemes are run by smaller companies with less technical and managerial capacity
Utility	• Responsibility lies with an experienced organisation • Often good links to policy; better access to legal systems • Their scale means that they may have better access to spare parts and maintenance	• Liberalisation means that they are market driven, so may not prioritise decentralised systems in poor rural areas • Often inefficient and bankrupt • Often driven by political agendas
Hybrid	• Combine the advantages of the models above, such as the technical expertise of a utility and the financial expertise of the private sector	• Differences in the management systems of each entity can lead to conflicts and increased transaction costs • Need stable partners, especially from the public domain

Community-based systems tend to be more common in countries where private sector or utilities remain absent, such as in Africa. Local communities usually lack the technical, business and organisational skills to operate and maintain systems. This approach needs a long preparation period and much capacity building to compensate the lack of skills and to increase cooperation between actors. Generally, community-run mini-grids have proven to be successful due to the positive impact it can generate in terms of self-governance (Rolland & Glania, 2011).

Another possibility is the private sector-led mini-grid. The primary advantage of this approach is that it usually provides electricity services more efficiently than any other model. However, profit margins for rural mini-grids are generally so slim that private sector involvement is often lacking. For isolated mini-grids, system location and scale, income profiles of potential customers, available subsidies, standardised administrative procedures and policies, and a strong marketing campaign, among other factors, dictate whether a project can attract private investors and/or operators (Rolland & Glania, 2011).

The utility-based approach, either owned by a national public institution, investor or a cooperative, is the most common for rural electrification in developing countries (Peskett, 2011). The principal advantage of this approach is that the responsibility lies with an experienced organisation with the needed financial and technical resources to oversee the project. Due to their (quasi-) public nature, utilities also directly benefit from a privileged legal position and have better access to financing. Some experts consider this model more likely to be successful because of economies of scope and scale that utilities can generate. There is also much scepticism about the effectiveness and efficiency of

utility-driven models. If utilities in Africa were to be the key actor in enabling full access to energy, electrification rates would have been much higher. And, although the liberalisation of the energy markets that has taken place in many of these countries has caused utilities to be more market-oriented and competitive, running remote mini-grids has certainly not become a priority due to their high-risk and low-revenue profile compared to urban electrification. Many of them are also operationally bankrupt, financially inefficient, and run the risk of being rejected by local communities and being unresponsive to local circumstances. Finally, utilities are often driven by political agendas. This can be an advantage when electrification is perceived as a political priority (Rolland & Glania, 2011).

The hybrid approach is a combination of the approaches above and aims to to maximise effectiveness and efficiency. Hybrid business models can be very diverse and may involve different entities owning and operating different parts of the system. For example, a utility or a private company could implement and own a clean energy mini-grid, whereas a community-based organisation manages it on a daily basis and a private company provides the technical back up and management advice (Peskett, 2011). The future of rural electrification probably lies in a mixture of the different business models, with the utility positioning itself as partner for the private sector and community-based organisations. This approach should however be adopted with care if it wants to be successful (Rolland & Glania, 2011). Because hybrid models combine different approaches they tend to exhibit more complex management systems (Peskett, 2011)

3.4.2. Social, economic and business issues

Successful financing and business models are key for enabling access to energy. The past 30 years of development policies in rural electrification generated some important lessons. Firstly, most projects were planned over the short term and without constellation of local communities, which resulted in marginalised uptake of energy services and eventually financial failure. Secondly, large capital subsidies and donations without a sustainable business plan sometimes destroyed local markets. The failure of traditional development policies, the inefficiency of the traditional utility-based energy market, as well as the tremendous investment needs in energy infrastructure has led to increased focus on sustainability and private sector participation (Rolland & Glania, 2011).

3.4.2.1. Operation and maintenance

Operation and maintenance are key components for achieving a financially sustainable project. Costs associated with electricity outages, e.g. lost revenues and spare parts, must be minimised and balanced against the costs of keeping the system in check. A rule of thumb suggests O&M costs are approximately 3-13% of annual capital costs (Rolland & Glania, 2011. If managed successfully proper O&M can prevent 5% of lost sales (IEA, 2014).

3.4.2.2. Business case development and access to finance

Mini-grid sustainability is closely linked to the issue of creating local small and medium enterprises (SME) with access to skills, equipment, financing and markets to sell their products. These issues lead

to the question of the role of companies in industrialised nations, which can stimulate development by supporting technology transfer, linking call for tenders with criteria of subcontracting or partnerships wilt local SME, providing technical and business training and by offering market facilitation to support business organisations (Rolland & Glania, 2011).

Local consumer, business and project financing should also be developed for mini-grids. The high-risk, low-revenue profile of most mini-grids need project developers and financial institutions to look into opportunities to ensure end-users are able to benefit and contribute financially to the O&M of mini-grids. If financing opportunities are to be effective they should address the following challenges. First of all, mini-grids are characterized by the diversity of business and financing models, which exhibit varying risk and return profiles. To secure financing, demonstration of the business model over a long period of time is needed. Secondly, mini-grids for people at the BoP face poorer economic forecasts, making the implementation of cost-reflective pricing more difficult and limiting the incentives for private investment (Peskett, 2011). Other, barriers include insufficient market capital, perceived high risk, high transaction costs for financing small projects, high interest rates and short tenors, high cost of equity finance, insufficient net worth and limited experience of firms, low liquidity, and difficulties in channelling large funds from multilateral development bank through local, small financial institutions (IRENA/ADB/ARE, 2014; Rolland & Glania, 2011).

3.4.2.3. Education and capacity building

Issues of information and education provision should not be limited to financing and therefore should be more widely addressed. A lack of proper information dispersal and technical, commercial and governance trainings can lead to performance losses of 30-35% on average (Peskett, 2011). Another important aspect is to promote participation of women through advocacy and awareness raising. Energy planning is often gender-blind, while most of the collection and utilisation of energy resources are carried out by women. Special focus should be put on ensuring women and men have equal access and control over resources, development benefits and decision-making at all stages of the project (ERPS, 2010). Gender issues are increasingly taken into account in the design of rural electrification projects in developing countries, but still affect a minority of energy projects. Only 20% of the projects in 1997-2006 have accounted for a clear impact on gender issues in their project design (World Bank, 2008b).

3.4.2.4. Business enabling environment and regulations

Policies to promote mini-grids are important for enabling the business environment. They should aim at providing a clear, long-term vision and commitment for rural electrification options, preferring either stand-alone systems, mini-grids or grid extension. This type of risk reduction makes it more interesting for private and public investors to invest (Rolland & Glania, 2011). In addition, since rural electrification can be expensive, many power operators serving local communities face a gap between cost and revenue streams. In some cases, this gap arises because regulations prohibit operators from cross-subsidising tariffs for different customer groups, such as (low-income) households and enterprises (higher income). It is important that tariffs maintain a balance between commercial viability and costumers' ability and willingness to pay (Tenenbaum, Greacen, Siyambalapitiya & Knuckles,

2014). Furthermore, a smart combination of subsidies and well-established tariff structures are key to ensure long-term project viability. They can support the investment, the connection, operation, and output. Adequately planned output-based aid (OBA) schemes, consisting of a subsidy planned directly in exchange for a service, can be used to stimulate private investments and to ensure O&M. There are supplementary measures needed, such as low import duties, tax credits, market studies, site surveys, and capacity building (Rolland & Glania, 2011).

4. Financing mini-grids

4.1. Cost and revenue streams

To be completed.

4.2. Investors and financial products

To be completed.

5. Results

5.1. The current role of development practitioners in mini-grids

This chapter starts with a brief summary and analysis of the services delivered by two development practitioners, namely SNV Netherlands Development Organisation and GVEP. A comparison between these two organisations and a preliminary general assessment for development practitioners in mini-grids is also presented. In addition, this section takes a broader perspective by using findings from the interview with a former Director of the ARE and author of the study on *'Hybrid mini-grids grids for rural electrification: lessons learned'* to compare results and thereby to increase the validity of the conclusions. In section 5.2, the author presents a summary and analysis of the mini-grid project financials of SNV Netherlands Development Organisation in Zimbabwe. It entails detailed financial information on 5 mini-grids, which altogether form the mini-grid project. From these data we learn how mini-grids are set up financially. In section 5.3, results taken from 2 interviews with investors experienced in mini-grid financing are presented and analysed to see why and under which circumstances they are willing to put money in mini-grids. Interview findings from a financial expert and mini-grid project leader from SNV Netherlands Development Organisation are used for the latter two sections to supplement conclusions on their respective topics.

5.1.1. Services per development practitioner

The author collected and analysed project documentation for 5 mini-grid projects of SNV Netherlands Development Organisation (SNV, 2014a/e), whereas an online questionnaire was used to gather data on the services of other development practitioners, see appendix 9.3. The author's experience in 2014 at SNV Netherlands Development Organisation is the main reason for the extended focus on this organisation. Through this experience, two other, yet similar development practitioners were identified: GVEP and Practical Action. Eventually, the author collected data only from GVEP.

Table 3 highlights the services delivered by the two development practitioners, including those delivered by their respective partner organisation(s) (SNV, 2014a/e; Van Holsteijn, 2015). Results of SNV Netherlands Development Organisation cover project-specific information, whereas those from GVEP contain a general classification of the service possibilities. Each of the service provisions are labelled depending on the organisation responsible for fulfilling that particular service; see the legend in table 3. The author distinguishes 3 general categories, namely the preparation phase, design phase, and post-installation advisory services.

Although table 3 provides an extensive overview of the service provisions, we need to sort out the dominant services in order to identify SNV Netherlands Development Organisation's core strength. One possible method, which is applied here, is to appoint only those services that are provided solely by SNV Netherlands Development Organisation in the majority of its projects. In this case a minimum of 3 out of 5 is applied. The author acknowledges the arbitrariness of this procedure. To sum up, the following core services were identified (SNV, 2014a/e):

Table 3. Mini-grid services performed by several development practitioners. Sources: SNV (2014a/e) and the online questionnaire.

Services*	SNV Netherlands Development Organisation				GVEP (1)		GVEP (2)
	Peru	Nepal	DRC	Zimbabwe	Rwanda	Africa	Africa; other region
Preparation							
Conducting feasibility studies to assess the potential of the mini-grid	■	■	■	■	❖	■	■
Identifying project stakeholders	■	○	■	○	○	○	○
Organising meetings with end-users for relationship building	○	○	○	○	○	○	■
Organising meetings with (potential) investors for relationship building	■	○	■	○	○	■	○
Organising meetings with relevant stakeholders to enable favourable mini-grid policies and regulations	-	■	■	-	-	■	■
Demonstrating the potential of the mini-grid to project stakeholders	■	■	■	■	○	■	■
Design							
Designing local management structures to ensure stakeholders fulfil their roles and responsibilities	○	❖	■	○	■	❖	○
Designing the technology (e.g. size, site selection)	○	○	❖	○	○	❖	❖
Performing installation and construction of the mini-grid	❖	❖	❖	❖	❖	❖	❖
Designing operation and maintenance procedures	○	○	○	○	○	○	❖
Advisory services							
Structuring finances for initial capital investment, O&M and replacement	○	■	■	■	-	■	■
Setting up tariffs and collection procedures for end-users to be able to pay for electricity	○	■		○	-	■	■
Creating linkages between financial institutions and the community to enable access to finance for end-users	-	■	■	■	-	■	■
Creating linkages with other markets and/or market actors	■	■	■	○	■	■	■
Providing business/commercial trainings to end-users	■	■	■	■		■	■
Providing education on rational energy use to end-users	■	■	■	■			○
Providing trainings on O&M of equipment to end-users	■	○	○	❖	○	■	❖
Monitoring and evaluating end-users' practical use of the mini-grid	■	○	■	■	○		○

■ = service provided by development practitioner

○ = service provided by development practitioner and partner organisation(s)

❖ = service provided by partner organisation(s)

'-' means no service is provided by the respective organisation, whereas a missing value implies missing data

- Preparation:
    - Conducting feasibility studies to assess the potential of the mini-grid.
    - Demonstrating the potential of the mini-grid to project stakeholders.
- Advisory services:
    - Structuring finances for initial capital investment, O&M and replacement.
    - Creating linkages between financial institutions and the community to enable access to finance for end-users.
    - Creating linkages with other markets and/or market actors.
    - Providing education on rational energy use to end-users.
    - Providing business/commercial trainings to end-users.
    - Monitoring and evaluating end-users' practical use of the mini-grid.

The online questionnaire yields merely 2 results: both from GVEP (Van Holsteijn, 2015). Although most of these results obtained in table 3 (i.e. GVEP (1) and GVEP (2)) show similarities, the differences in responses do not justify a solid, general conclusion. First of all, this might be due to the low number of respondents. Secondly, although the questionnaire explicitly mentioned which of the listed services could be provided by the organisation in Africa, we do not know whether respondents delivered information about the organisation's services from a project-specific or general point of view. The author could have controlled for this by including this issue in the questionnaire. A conservative approach for the analysis therefore seems appropriate. Before the comparison was made, the author decided that each service must be labelled as *'service provided by development practitioner'* for both questionnaire results for the individual services to be categorised as core strengths of GVEP. The key services that were identified are:

- Preparation:
    - Conducting feasibility studies to assess the potential of the mini-grid.
    - Organising meetings with relevant stakeholders to enable favourable mini-grid policies and regulations.
    - Demonstrating the potential of the mini-grid to project stakeholders.
- Advisory services:
    - Structuring finances for initial capital investment, O&M and replacement
    - Creating linkages between financial institutions and the community to enable access to finance for end-users.
    - Creating linkages with other markets and/or market actors.
    - Providing business/commercial trainings to end-users.

5.1.2. Comparison and overall assessment

Both SNV Netherlands Development Organisation and GVEP have much in common in terms of core strengths, despite the selection boundaries mentioned in the previous paragraph. A comparison based on these two organisations results in the following key services (SNV, 2014a/e; Van Holsteijn, 2015):

- Preparation:
    - Conducting feasibility studies to assess the potential of the mini-grid.
    - Demonstrating the potential of the mini-grid to project stakeholders.

- Advisory services:
  - Structuring finances for initial capital investment, O&M and replacement.
  - Creating linkages between financial institutions and the community to enable access to finance for end-users.
  - Creating linkages with other market and/or market actors.
  - Providing business/commercial training to end-users.

Most of these services (4 out of 6) belong to the post-installation advisory services, whereas the remaining ones (2 out of 6) fall under the preparation phase. One can clearly see these are the focal areas of both development practitioners, whereas the design phase is not. Note that only SNV Netherlands Development Organisation is the sole organisation fully responsible for the monitoring and evaluation processes. The design phase can be defined as the process where the technological mini-grid hardware is implemented. All projects of SNV Netherlands Development Organisation use local and/or national technical partners for these services, whereas its projects in Peru and Zimbabwe receive technical assistance from another international development practitioner: Practical Action. Relevant information for GVEP was not obtained.

5.1.3. Supplementary information – interviews

This study gathered information from an interview with a former Director of the ARE and author of the study *'Hybrid mini-grids for rural electrification: lessons learned'* (Rolland, 2015; see appendix 9.4). The author asked which major issues are needed for the implementation of mini-grids, as well as to link these to the role of development practitioners. An important note from the interviewee was that mini-grids are part of an economically attractive strategy for people at the BoP compared to grid-extension, of which prices are typically 30-50% higher, sometimes even double as expensive. Still, many challenges exist, such as described in the literature review. The list below shows implementation issues forthcoming from the interview, including a short description of the associated barriers:

- Access to finance. One major problem includes interest rates of local commercial banks across Africa, which are often >30% due to inflation, risk perception and lack of interest. In addition, subsidies remain needed at early implementation stages to cover high capital investment costs.
- Local market development is important to ensure presence of small enterprises to take electricity and generate income. No barriers mentioned.
- Regulations play a role, but it is not considered as a critical element. Still, a solid long term rural electrification vision is lacking as well as quality standards to enable entry by new firms and future connectivity to the main grid, and the ability of having different tariff structures for end-users in rural areas compared to urban areas. If the latter is not present it implies that poor, rural communities are not able to pay for electricity. This means not only subsidies are needed, but it also puts a restraint on the attractiveness of mini-grid towards investors.
- Feasibility studies; play a role but no critical element. No barriers mentioned.
- Technology is no issue at all; there are plenty of engineering firms capable of designing, installing and constructing the technological hardware. No barriers mentioned, also not for operation and maintenance procedures.

Therefrom are formulated the following conclusions for development practitioners (Rolland, 2015).

- Development practitioners should play a role in areas where commercial project developers are absent. They are not driven by commercial interests but rather by social development impacts, specifically for the people at the BoP. In a practical sense this means they could have an added value in isolated areas characterised by a low population density and a lack of a local private sector.
- Development practitioners should promote productive uses of electricity to increase commercial and financial sustainability of mini-grid projects.
- Banks and other investors are essential in directing financial feasibility studies in conjunction with local entrepreneurs to create a financial mini-grid programme. Development practitioners could play a role in linking these actors as well as conduct (financial) feasibility studies and demonstrations to raise understanding and acceptance by local banks.
- Regulations should be part of feasibility studies and lobbying activities so that all stakeholders (e.g. end-users, investors) have a clear and stimulating vision as well as a realistic perspective on the possibilities for delivering mini-grid projects. This is also important for scaling up mini-grids.
- As a concluding note, sustained demonstration and communication play an important role to convince and gather stakeholders. If development practitioners want to create value they need to show mini-grids are technically, commercially and financially sustainable. That is the beauty and difficulty of the mini-grid sector: a lot of stakeholders are needed for proper scale and impact.

The interview with SNV Netherlands Development Organisation, which is mainly used for the upcoming section, holds similar conclusions (Keshav, 2015; see appendix 9.4). The author asked why development practitioners should be the ones working on mini-grids for people at the BoP. From the interview can be concluded that development practitioners similar to SNV Netherlands Development Organisation have a particular added value in delivering advisory services. And, they aim to balance the expectations of BoP communities with the attractiveness of investments for the financial sector, and better understand community development than other organisations such as consultancy firms, which focus merely on the financial implementation.

5.2. Financials mini-grid project Zimbabwe

If we want to learn to what extent development practitioners can enable financing for clean energy mini-grids we need to understand how mini-grid projects are developed financially, where the financial gaps are in the lifetime of mini-grids, and how these gaps can be worked out. In the next section the author analyses the mini-grid project of SNV Netherlands Development Organisation in Zimbabwe, which consists of 5 separate mini-grids. The main reason for this focus is that the project strives to achieve a business model that ensures financial and economic sustainability in rural areas in Zimbabwe (SNV, 2014k). The author used 5 financial proposal reports for the case studies Mashaba, Samanga, Gachegache, Nyamuzizi and Tshitulipasi respectively (SNV, 2014f/j).

5.2.1. Financial analysis

A first glimpse at the data in table 4 reveals a difference between project duration, i.e. implementation phase, and the lifetime of the mini-grids, which are 5 and 30 years respectively (SNV, 2014f/k). While doing the analysis the author discovered that the overall project costs and total mini-grid infrastructure costs vary significantly, by US$ 3-3.7 million per project. The overall project intends to establish a pilot based on a commercial business model, which should eventually lead to replication in other areas. For doing so ancillary support is needed by development practitioners, among others, implying additional costs. The support services for Zimbabwe can be found in table 3 in section 5.1.1 and in the associated budget proposal (SNV, 2014k). Unfortunately, the author was not able to identify the specific added value of those services for the mini-grid project sites and the effects on external, future mini-grids, such as arising from policy lobbying activities.

A second point of attention is the discrepancy between total mini-grid infrastructure costs and the costs assigned to local communities: US$ 0.5-0.9 million. This is due to grants provided by multilateral and bilateral organisations. On average, they cover 34% of the infrastructure costs and 80% of the overall project costs. Only the Samanga project bears higher community costs than total mini-grid costs due to the fact that excess energy can be sold to the main grid, leading to additional community revenue. Although we are analysing a pilot project, a first tentative conclusion is that commercial and financial sustainability for the mini-grids is a matter of framing since communities bear only a small fraction of the total costs.

Table 4. Overview Zimbabwe project. Sources: SNV (2014f/k).

	Mashaba	Samanga	Gachegache	Nyamuzizi	Tshitulipasi
Technical data					
- Power technology	PV	Hydro	PV	PV	Geothermal/PV
- Size	100 kW	100 kW	100 kW	100 kW	150 kW
- Project duration	5 years	5 years	5 years	5 years	5 years
- Lifetime mini-grid	30 years	30 years	30 years	30 years	30 years
Financial data					
- Overall project costs	4.960.952	4.178.139	4.318.389	4.660.139	5.654.334
- Total mini-grid costs	1.479.544	1.028.044	1.228.044	1.428.044	1.929.544
- Community costs	592.258	1.214.540	721.987	722.526	1.423.031
- Community loan	439.772	1.028.044	565.424	565.424	1.229.544
- Annual loan instalments	87.954	205.608	113.084	113.084	245.908
- Community revenues	687.921	1.958.447	746.776	782.713	2.083.113

One of the key elements in the project is the inclusion of small enterprises in the business model to generate income and to allow subsidising of low-income households. Other user types include public services and external buyers for excess energy, see table 5 in appendix 9.1 (SNV, 2014f/j). This table also shows the annual consumption, tariff rates and revenue per user type for a period of 30 years. Note that all data is constant over time (SNV, 2014f/j). One can observe that the Samanga and Tshitulipasi projects have many more households than the other sites: 200 versus 7-8. Every household is expected to pay a price of US$ 0,09-0,11 per kWh. Their annual consumption levels of 2,128,5 kWh is sufficient to be able to lead to modern energy services, see figure 3 in section 3.1 (AGECC, 2010).

Enterprises generally pay higher prices per kWh compared to households, namely US$ 0,09-0,20. If we multiply the consumption and tariff rates per user type we obtain the annual revenues as presented in table 6. Samanga and Tshitulipasi create more than 50% of the revenue through households' equity, whereas for the other project sites this equals less than 10%. The Mashaba, Gachegache and Nyamuzizi project sites are dependent on enterprises, which is clear given the respective 80% of annual revenues. For the overall project the author calculated that more than half of the revenues flow from enterprises (54,2%).

Table 6. Annual revenues per category Zimbabwe project. Sources: SNV (2014f/j).

	Households	Public services	Enterprises	External sales	Total
Revenues (US$)					
Mashaba	1.638	950	27.791	3.712	34.093
Samanga	38.313	1.267	21.552	3.252	64.384
Gachegache	1.532	633	19.490	2.710	24.366
Nyamuzizi	1.532	1.584	22.683	2.710	28.510
Tshitulipasi	38.313	1.900	31.499	3.252	74.965
Revenues (%)					
Mashaba	4,8	3,2	81,1	10,8	100,0
Samanga	59,4	2,2	33,4	5,0	100,0
Gachegache	6,2	3,2	79,5	11,1	100,0
Nyamuzizi	5,3	6,1	79,1	9,5	100,0
Tshitulipasi	51,0	2,7	41,9	4,3	100,0
Total (project)	**35,8**	**3,1**	**54,2**	**6,9**	**100,0**

Most of the costs take place in the first 5 years, i.e. the implementation phase, to cover the capital expenses of the mini-grid infrastructure (SNV, 2014f/j). This is due to 5 linear instalments of the loans. See table 4 for loan amounts. It is yet unclear which party bear these costs initially. The author suggests a third party functions as a mediator between the financial institutions and the community. Local communities probably do not have the equity available to pay the instalments, but baseline income data to verify this is absent. We do know that the annual loan payments are at least double the size of the annual community revenues, see table 4. Moreover, the fact that soft loans against 1% interest are provided gives an indication of the lack of access to finance by local end-users. Other large costs from high to low include salaries and spare parts for operation and maintenance, which are equal amounts per project site of US$ 106.990 and US$ 18.000 respectively across the mini-grid lifespan, and interest payments of 1% on outstanding loans (SNV, 2014f/j).

The project overall claims to cover all community costs in a timeframe of 5 years, whereas the financial reports show that only the annual revenues outweigh the annual expenses after year 5 (SNV, 2014f/j). The latter argument is valid, see figure 4 in appendix 9.2. As figure 5 and table 6 show, the projects need at least 16 years to breakeven. This is not surprising given the low IRR (internal rate of return) estimates for the projects, varying from 0,34% to 6,92%. The IRR measures the profitability of investments and explains how much return can be paid to the financial shareholders. A larger IRR leads to improved returns and more interested investors. Note that the IRR already takes into account the 1% interest payments of the soft loans, which means the IRR should be slightly higher. The author speculates that the low IRR's might have led to the absence of private investments. Another note is that we do not have baseline studies that investigate whether or not the emergence of the mini-grids

has led to higher profitability compared to alternative solutions. Furthermore, one can see that Samanga and Tshitulipasi, with revenues coming mostly from households, generate by far larger profits and better IRR's compared to the other project sites. This seems contrary to what is the purpose of the whole project, namely establishing a commercially driven business model around productive, income-generating enterprises. Unfortunately, there is no clear evidence why Samanga and Tshitulipasi are financially better off.

Figure 5. Net revenues Zimbabwe project.

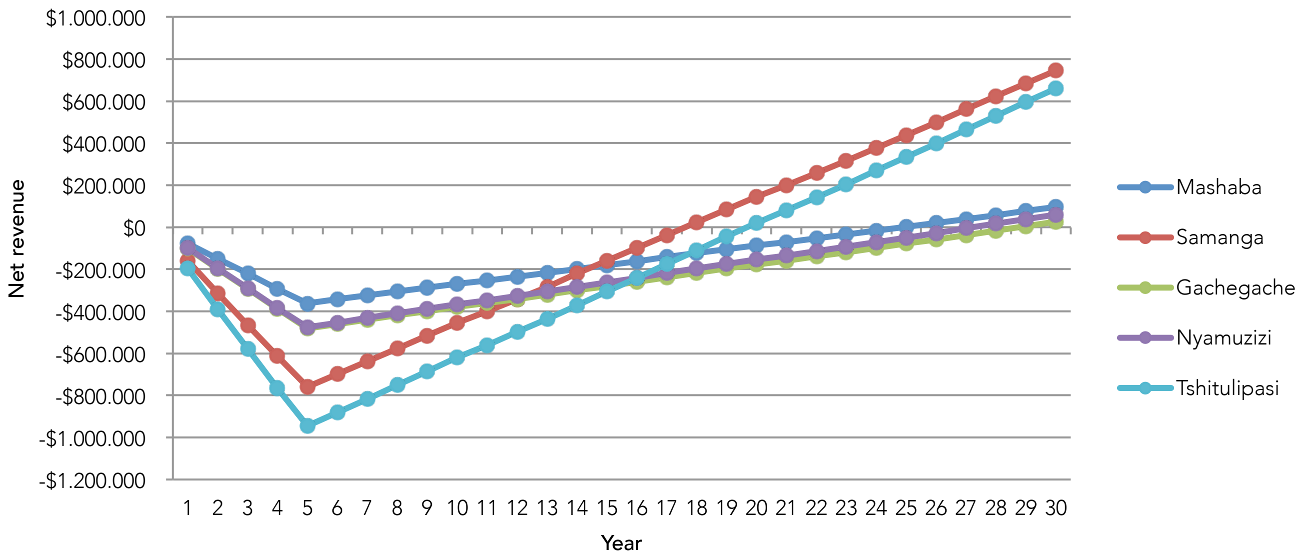

Table 5. Profitability Zimbabwe project.

	Breakeven year	Internal rate of return (%)*	Profit at year 30 (US$)
Mashaba	25	1,61	95.647
Samanga	18	5,06	743.907
Samanga**	16	6,92	1.034.284
Gachegache	29	0,34	24.790
Nyamuzizi	28	0,80	60,178
Tshitulipasi	20	3,82	660.082

* The internal rate of return already includes the 1% interest instalments. The rate should therefore be slightly higher
** Under the condition that the Samanga project site succeeds to sell its excess energy to the main grid

5.2.2. Supplementary information – interview

The list below presents findings from the interview with SNV Netherlands Development Organisation and is used to reflect on the financial analysis for the Zimbabwe project (Keshav, 2015):

- Mini-grids for people at the BoP can potentially be financially viable solutions with sizes over 5 kW that serve at least 50 households. For most of those households an annual electricity fee of €24 is considered very high. The Zimbabwe project, with sizes over 100 kW per mini-grid and household bills of US$ 191,57 a year can be considered a large project intended for wealthier clients. This might explain why the Samanga and Tshitulipasi projects generate

higher project returns than others. Technically speaking though, those households could still fall under the definition of BoP: The BoP limit is set at a maximum of US$ 2,50 per day, or US$ 912,50 annually, which is considerably higher than the annual electricity bill of US$ 191,57.

- In countries such as Nepal, grant funding provides 40-50% of the total costs. Compared to Zimbabwe, with an average cost coverage of 80% by grants, this is very low. This number is based on the fact that the overall project costs, which are subsidised, are 80% higher than the community-level costs.
- The amount of grant funding is negatively related to IRR's of projects. In Nepal, projects usually exhibit IRR's of 15%. Breakeven within 3 years is not unusual and stands in big contrast with Zimbabwe (>16 years). Moreover, if projects do not generate profits within 10 years, investors are not likely to participate. However, the interviewee's experience also suggests that breakeven points of 3-5 years can be achieved in Africa. In case of financial sustainability of projects within this timeframe, donor funding should only be 20% in the form of technical assistance.

5.3. Investors and mini-grids

To be completed.

6. Discussion

The analysis yields many discussion points, both expected as well as unexpected. Let us look at the challenges, among those that are mentioned in the methodology in chapter 2, and how they were dealt with. What the author described as the most difficult challenge was to identify and analyse data on the costs of the mini-grid infrastructure and services, particularly those provided by development practitioners. All the costs were known, but they could not be linked to the benefits for communities as a result of the mini-grid.

In addition, the author could not identify individual income patterns in the Zimbabwe case study and we can thus not determine if the project occurs in the context of people at the BoP. The interview with SNV Netherlands Development Organisation shows that they work specifically for people at the BoP and that these people generally provide 30% of the capital needed to ensure viability of mini-grids. Still, the author is reluctant to draw general conclusions on the investments (i.e. revenues) needed from community members, based on the results of this study.

It was also quite surprising to discover from the project data that communities pay only 20% of the total costs. The author wonders if the remaining 80%, which is financed through grants, could lead to more cost-efficient replication to other, future mini-grid sites. This could occur through active policy lobbying, for example. In that case, mini-grids would be financed more from community funds. Again, do to the limited data, as well as the bounded timeframe, the author could not detect this effect. Furthermore, the author did not succeed in identifying whether grant funding is likely to be available for future projects.

Another challenge was to gather information on the services provided by development practitioners, other than SNV Netherlands Development Organisation. Not only because the author identified merely two other development practitioners active in mini-grids, but perhaps also due to the fact that communication was done via e-mail. With 7 results, 5 and 2 from SNV Netherlands Development Organisation and GVEP respectively, the author has to be cautious with drawing general conclusions on the role of development practitioners. Subsequently, this study only focused on the link between development practitioners and investors, rather than analysing the relationships of other actors with investors. The author therefore sought for a niche role for development practitioners.

Discussion financing part: to be included.

7. Recommendation and conclusions

Now that the analysis is done the findings from the literature review and this study's results are put together, as to make general conclusions and recommendations. But first of all, let us look back at the objective of this study. The author aimed to articulate a framework providing the steps needed to secure financial sustainability of clean energy mini-grids for people at the BoP in Africa. The main purpose of this framework is to be adopted by development practitioners to help improve services for mini-grids. To fulfil this objective this study adopted the following main and sub research questions:

- To what extent can development practitioners help to attract financing for clean energy mini-grids for Africa's poor, rural communities?
    - What are clean energy mini-grids and what is their relevance for poor, rural communities?
    - Which key issues need to be addressed for clean energy mini-grids to be able to create economic development?
    - How can additional financing address those key issues?
    - What is currently the role of development practitioners in the implementation of mini-grids?
    - How can development practitioners help to improve participation of investors?

Step by step, the author analysed literature, project documentation, as well as conducted interviews and a questionnaire to answer each of the sub questions and the main research question. Starting with the first one, this study identified the scale of rural electrification problems in Africa, which are greater than anywhere else on the planet. Clean energy mini-grids have been specifically called a solution to rural electrification for people at the BoP; hence the chosen focus on renewable energy. However, this study does not argue that clean energy sources are preferred over diesel-based ones. Also, it is difficult to appoint mini-grids as the Holy Grail compared to solar home systems and grid extension, due to the context-specific conditions. This rather underrated aspect has a big, long-term economic impact. A solid justification for mini-grids would reduce risks for the stakeholders involved, such as for investors, and is therefore likely to attract more interest from different parties.

This study also derived the key lessons learned, mostly from primary sources in the field, i.e. electrification practitioners. They acknowledge that mini-grids are most likely to be implemented successfully through help in setting up a sound governance structure, efficient O&M procedures, a local market with SME, access to consumer, business and project finance to ensure operation, capacity building of local communities, and favourable mini-grid regulations. Based on a project analysis of development practitioners and interviews, the author concludes that development practitioners have a clear added value in helping people, specifically at the BoP, to secure long-term and appropriate use of electricity services. Compared to commercially driven stakeholders, such as consultancy firms, development practitioners better understand the needs of poor, local communities, and at the same time are capable of delivering the required advisory services to overcome relevant challenges.

Further conclusions, particularly for the financing section: to be included.

Framework included once financing recommendations and conclusions are made.

Main research question can be answered once financing recommendations and conclusions are made.

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9. Appendix

9.1. Tables

Table 1. Rural electrification benefits, measured in US$ per household per month. Source: World Bank (2008b).

Benefit	Philippines	Peru	Laos	Bolivia
• Lighting	7.36	16.16	5.60	12.24
• TV	15.11	8.50	2.22	4.00
• Radio	Included in TV	Not estimated	Not estimated	Not estimated
• Education	12.46	Not estimated	Not estimated	Not estimated
• Time savings for households	5.30	5.50	5.50	US$ 5.50
• Productivity home businesses	13.55	0.00	5.75	Not estimated
• Improved health	0.00	0.02	0.02	Not estimated
• Reduced fertility	Not estimated	0.08	0.08	Not estimated
• Increased agricultural productivity	0.00	0.00	Not estimated	Not estimated
• Public goods benefits (including security)	Not estimated	Not estimated	Not estimated	Not estimated
• Reduced pollution (global benefits)*	Not estimated	0.24	0.15	0.20
Total	53.78	30.50	19.32	21.94

* Applies only to off-grid beneficiaries. Assumes 0.6 ton of CO_2 /MWh priced at US$8/ton of CO_2.

Table 5. Annual revenues Zimbabwe project.* Sources: SNV (2014f/j).

	Households	Schools	Clinics	Energy kiosks	Shops	Grinding mills	Lodges
Total users**							
Mashaba	7	3	1	4	3	3	0
Samanga	200	4	1	4	10	3	0
Gachegache	8	2	1	3	3	2	0
Nyamuzizi	8	5	1	4	6	2	0
Tshitulipasi	200	6	1	6	6	4	1
Consumption (kWh)							
Mashaba	2.128,5	198	1.716	3.960	825	14.932,5	0
Samanga	2.128,5	198	1.716	3.960	825	14.932,5	0
Gachegache	2.128,5	198	1.716	3.960	825	14.932,5	0
Nyamuzizi	2.128,5	198	1.716	3.960	825	14.932,5	0
Tshitulipasi	2.128,5	198	1.716	3.960	825	14.932,5	18.067,5
Tariffs (US$/kWh)							
Mashaba	0,11	1,60	0,09	0,20	0,15	0,15	0
Samanga	0,09	1,60	0,09	0,20	0,09	0,09	0
Gachegache	0,09	1,60	0,09	0,20	0,15	0,15	0
Nyamuzizi	0,09	1,60	0,09	0,20	0,15	0,15	0
Tshitulipasi	0,09	1,60	0,09	0,20	0,09	0,09	0,09
Revenues (US$)							
Mashaba	1.638,95	950,40	154,44	3.168,00	371,25	6.719,63	0
Samanga	38.313,00	1.267,20	154,44	3.168,00	742,50	4.031,78	0
Gachegache	1.532,52	633,60	154,44	2.376,00	371,25	4.479,75	0
Nyamuzizi	1.532,52	1.584,00	154,44	3.168,00	742,50	4.479,75	0
Tshitulipasi	38.313,00	1.900,80	154,44	4.752,00	445,50	5.375,70	1.626,08

* Table continues on next page

** Total users do not match the total number of people connected to electricity, but rather corresponds to the number of electricity connections

	Processing plants	Fruit pulp businesses	Fishing camps	Coldrooms	Irrigation schemes	Offtaker customer	National grid	Total
Total users*								
Mashaba	0	0	0	0	3	2	0	26
Samanga	0	2	0	5	0	2	0	231
Gachegache	0	0	1	2	1	1	0	24
Nyamuzizi	1	0	0	0	2	1	0	30
Tshitulipasi	2	0	0	0	4	2	0	232
Consumption (kWh)								
Mashaba	0	0	0	0	58.443	12.375	0	94.578
Samanga	0	51.067,5	0	9.817,5	0	18.067,5	26.317,5	129.030
Gachegache	0	0	51.067,5	9.817,5	11.055	18.067,5	0	113.767,5
Nyamuzizi	51.067,5	0	0	0	22.110	18.067,5	0	115.005
Tshitulipasi	51.067,5	0	0	0	11.055	18.067,5	0	122.017,5
Tariffs (US$/kWh)								
Mashaba	0	0	0	0	0,10	0,15	0	-
Samanga	0	0,09	0	0,09	0	0,09	0,09	-
Gachegache	0	0	0,15	0,15	0,15	0,15	0	-
Nyamuzizi	0	0	0	0	0,15	0,15	0	-
Tshitulipasi	0	0	0	0	0,09	0,09	0	-
Revenues (US$)								
Mashaba	0	0	0	0	17.532,90	3.712,50	0	34.248,06
Samanga	0	9.192,15	0	4.417,88	0	3.252,15	0	64.539,09
Gachegache	0	0	7.660,13	2.945,25	1.658,25	2.710,13	0	24.521,31
Nyamuzizi	7.660,13	0	0	0	6.633,00	2.710,13	0	28.664,46
Tshitulipasi	15.320,25	0	0	0	3.979,80	3.252,15	0	75.119,72

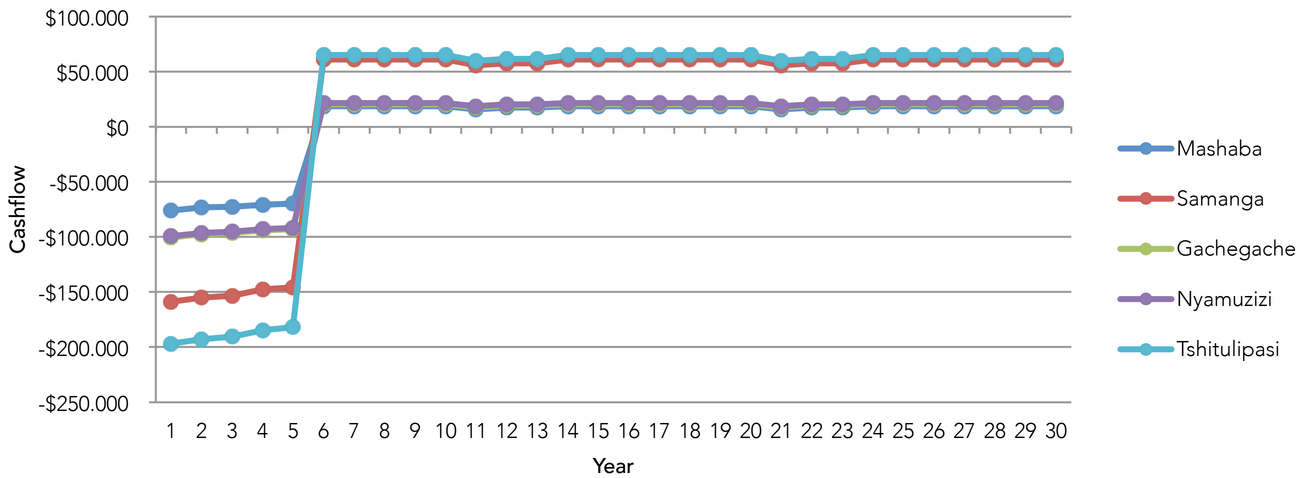
* Total users do not match the total number of people connected to electricity, but rather corresponds to the number of electricity connections

Table x: IED Reference Costs for Green Mini-Grids (GMG). For financing section. Delete?

Technology	Size range (kW)	Capital costs (US$/kW)	Levelised cost of electricity	Operating time (hours/year)
Diesel genset	5 – 300	500 – 1500	0.3 – 0.6	Any
Hydro	10 – 1000	2000 – 5000	0.1 – 0.3	3000 – 8000
Biomass gasifiers	50 – 150	2000 – 3000	0.1 – 0.3	3000 – 6000
Wind hybrid	1 – 100	2000 – 6000	0.2 – 0.4	2000 – 2500
Solar hybrid	1 – 150	5000 – 10000	0.4 – 0.6	1000 – 2000
LV distribution	400V	5,000 – 8,000 /km	A rough estimate of the required length is 30 customers per kw	
Connection costs	US$ 350 per customer			
MV distribution	33kV	13,000 - 15,000	US$/km	

9.2. Figures

Figure 4. Net annual cash flows Zimbabwe project.



9.3. Questionnaire

Page: 1

Decentralised electricity generation and distribution through mini-grids is becoming increasingly important for delivering modern energy services for rural communities in developing countries. Via this questionnaire I would like to understand which services your organisation delivers for mini-grid projects. Your answers will be part of my Master Thesis "Clean energy mini-grids for Africa's poor, rural communities" at the VU University of Amsterdam.

This questionnaire will take no more than 10-15 minutes of your time. Your answers are 100% anonymous and will not be shared among users other than the author of this questionnaire. Please do not forget to submit your answers at the end (bottom of the next page). For further contact, do not hesitate to reach me via mail: r.van.holsteijn@student.vu.nl.

Start

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1.

What is the name of your organisation? Please use the designated text box below. *

2.

Do you have practical experience in delivering services for mini-grid projects in developing countries? Multiple answers are possible.

- ☐ No
- ☐ Yes, in Africa
- ☐ Yes, in Latin America
- ☐ Yes, in Asia
- ☐ Yes, elsewhere

3.

The following table contains a selection of services you and/or your partner organisation(s) could deliver for mini-grid projects in Africa. Please tick the type of organisation that seems most relevant to you for performing each of these services, if relevant. You are able to tick more than one answer per service.

	Own organisation	Other organisation(s)	No organisation	Not sure
Conducting feasibility studies to assess the potential of the mini-grid	☐	☐	☐	☐
Identifying project stakeholders	☐	☐	☐	☐
Organising meetings with end-users for relationship building	☐	☐	☐	☐
Organising meetings with (potential) investors for relationship building	☐	☐	☐	☐
Organising meetings with relevant stakeholders to enable favourable mini-grid policies and regulations	☐	☐	☐	☐
Demonstrating the potential of the mini-grid to project stakeholders	☐	☐	☐	☐
Designing local management structure to ensure stakeholders fulfil their roles and responsibilities	☐	☐	☐	☐
Designing the technology (e.g. size, site selection)	☐	☐	☐	☐
Performing installation and construction of the mini-grid	☐	☐	☐	☐
Designing operation and maintenance procedures	☐	☐	☐	☐
Structuring finances for initial capital investment, operation, maintenance and replacement	☐	☐	☐	☐
Setting up tariff structure and collection procedures for end-users to be able to pay for electricity	☐	☐	☐	☐
Creating linkages between financial institutions and the community to enable access to finance for end-users	☐	☐	☐	☐
Creating linkages with other markets and/or market actors	☐	☐	☐	☐
Providing business/commercial trainings to end-users	☐	☐	☐	☐
Providing education on rational energy use to end-users	☐	☐	☐	☐
Providing trainings on operation and maintenance of equipment to end-users	☐	☐	☐	☐
Monitoring and evaluating end-users' practical use of the mini-grid	☐	☐	☐	☐

4.

Would you describe in a few sentences the specific added value your organisation could have for mini-grid projects in Africa? Please use the text box below. *

5.

If you have any comments, feel free to leave them in the text box below.

Please click this button to submit your answers

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Thank you for your cooperation. Your answers will be treated with full confidentiality. For further contact you can reach me via mail: r.van.holsteijn@student.vu.nl.

9.4. Interviews

Interview summary – (Rolland, 2015):

- Rural electrification alternatives such as mini-grids are economically attractive compared to grid-extension, of which prices are generally 30-50% higher and sometimes even double as expensive.
- Main challenges in the implementation of mini-grids are generally access to finance and local market development. Several problems regarding access to finance are the interest rates of >30% by local commercial banks across Africa, primarily because of inflation, risk perception and lack of interest. When it comes to regulations mini-grids lack a solid long-term vision of the rural electrification outlook, quality standards to enable entry by new firms as well future connectivity to the main grid, and the ability of differentiated tariff structures compared to national tariffs. The latter could imply that poor, rural communities are not able to pay for electricity. This means not only subsidies are needed, but also puts a restraint on the attractiveness of mini-grid projects towards investors.
- Regulations as well as proper market and financial feasibility studies play a role, but are not considered major obstacles in the implementation.
- Technology on the other hand is no issue; plenty of engineering firms capable of designing, installing and constructing the technological hardware.
- Subsidies remain needed at early stages to cover the gap between electricity expenses and revenues.
- Local market development is important to ensure presence of small enterprises to take electricity and generate income.
- Development practitioners could have a clear role in promoting productive uses of electricity to increase financial sustainability of mini-grid projects.
- Banks, as well as other investors, are essential in directing financial feasibility studies in conjunction with local entrepreneurs to create a financial mini-grid programme. Development practitioners could play a role in linking these actors as well as conduct feasibility studies and demonstrations to increase understanding and acceptance by local banks. Regulations should also be part of feasibility studies, so that all stakeholders have a clear vision and realistic perspective on the possibilities for delivering mini-grid projects. This is furthermore important for scaling up mini-grids.
- Development practitioners could play a role in areas where commercial projects developers are absent. Development practitioners are not driven by commercial interests but rather by social development impacts, specifically for people at the BoP. Thus, development practitioners could have an added value in areas characterised by a low population density and lack of a local private sector.

Interview summary – (Keshav, 2015):

- If BoP mini-grids are to be financially viable they should comprise over 5 kW of electrical power and serve over 250 people.
- A €2 monthly electricity fee is very high for households. Productive uses of electricity are needed so that SME, who can pay a higher fee due to income-generating activities, make mini-grids financially viable.

- In that case, financial institutions are more willing to provide finance. Since credit does not need to be provided to each individual household, transaction costs can be reduced.
- In Nepal, 50% of the financing is grant money, whereas the other half is provided by a commercial bank in the form of an 11% interest-bearing credit. In the succeeding program, grant funding and commercial credit is reduced to 40% and 30% respectively, whereas the remaining 30% comes from community level equity (i.e. end-users). The IRR for this project with the 40%-30%-30% financing structure is 15%, which takes into account the interest payments on the commercial credit. Generally, interest rates on commercial credit vary from 14-18% so that positive IRRs should be obtained.
- Break-even can be reached after year 3; a conservative estimate for both Nepalese and African standards.
- In a least developed country where economic growth is still in its infancy donor intervention is inevitable. At the same time, it might be possible to have 100% equity funded projects. If projects are to be truly sustainable after 3-5 years of implementation, there should only be 20% donor intervention in the form of technical assistance. 30% should be from users' equity and 50% from other equity sources.
- SNV observed that communities are willing to invest but they do not know how to connect with economic markets. SNV therefore emphasises on delivering advisory services such as accounting, market development, market linkages, branding and other business-oriented trainings.
- The interviewee was asked to see if the following financing sources could contribute to mini-grids. Clean Development Mechanism (carbon financing): no. Public donors: no. Public donors are not prioritising relatively small projects such as mini-grids. Equity from users will be an increasing trend. If future projects reach electricity generation levels of 30-800 kW private sector companies are more likely to make investments because of higher project profits.
- Initially, private banks did not understand that mini-grids are bankable projects. SNV came with an approach so that these projects were both understood and accepted by the banks.
- SNV is systematically working on creating awareness among financial institutions to show a sustainable approach is being pursued, implying higher value for money on the long run compared to smaller, short run projects (e.g. hygiene facilities).
- Most important criteria for investors to make an investment, as perceived by SNV, are: 1) mini-grid projects should be financially viable; 2) the project is generating money in a 10-year period; In addition, projects must exhibit a lifetime of at least 20 years to decrease interest rates on loans.
- The particular added value of SNV is that they understand community development better. Whereas consultancy firms merely focus on the financial implementation, SNV aims to balance the expectations of communities with the attractiveness of investments for the banking sector.
- Due diligence provided by financial institutions is the sole aspect in measuring and decreasing investors' risks. SNV helps them through the provision of technical, socio-economic and productive end-use guidelines, which is to be followed by both communities as well as SNV.

Interview summary – (Pit, 2015).

To be completed.

Interview summary – (Postma, 2015)

To be completed.